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(54) PIEZOELECTRIC OSCILLATOR AND ITS MANUFACTURE

(57)Abstract:

PROBLEM TO BE SOLVED: To manufacture a piezoelectric oscillator, capable of stably joining an electrode pad on the side of insulation substrate to the electrode of a piezoelectric diaphragm, and dispensing with the complicated jointing method without adversely affecting various characteristics of the piezoelectric oscillator.

SOLUTION: Electrode pads 14 are formed on the surface of an insulation substrate 1 side by side, in a width direction of the insulation substrate. On an upper surface of each electrode pads 14, metal bumps 31, 32 and 33 consisting of a wire bump wire are formed using gold. Crystal resonators 2 are mounted on the metal bumps 31 and 32 so that leading electrodes 21b (22a) are made to contact with each other. A ultrasonic wave welder welds an extension part 33a and the extraction electrode on the crystal resonator 2, and the metal bumps 31 and 32 and the extraction electrode of the crystal resonator 2.

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#### **CLAIMS**

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[Claim(s)]

[Claim 1] An insulating substrate and at least two electrode pads formed in the top face of an insulating substrate, While at least two excitation electrodes are formed in a principal plane with at least two leading electrodes which are connected to each electrode pad and an electric target concerned, and are connected with the exterior, and two or more metal bumps formed in the top face of each of said electrode pad It consists of a piezo-electric diaphragm with which the drawer electrode which leads each excitation electrode concerned to the edge was formed. Said two or more metal bumps are the piezoelectric transducers which carry in the upper part and come to carry out electric mechanical connections to the metal bump concerned respectively a part about said piezo-electric diaphragm. Some metal bumps [ at least ] where a piezo-electric diaphragm is not located in the upper part among said two or more metal bumps The piezoelectric transducer with which it has the expanding section which the metal bump upper part elongated, and the expanding section concerned, the drawer electrode of the top face of said piezo-electric diaphragm and the drawer electrode located in the underside of a piezo-electric diaphragm at a list, and a metal bump are characterized by

ultrasonic thermocompression bonding or carrying out ultrasonic welding.

[Claim 2] It is the piezoelectric transducer according to claim 1 which said metal bump is a wire bump and is characterized by said expanding sections being some wires.

[Claim 3] It is the piezoelectric transducer of claim 1 and two publications characterized by the expanding section of said metal bump and a metal bump being gold at the maximum upper layer of said electrode pad and a drawer electrode, and a list.

[Claim 4] The insulating substrate by which at least two electrode pads were formed in the top face, and two or more leading electrodes which are connected to said each electrode pad and electric target, and are connected with the exterior were formed in the underside is installed in an activity stage. While using the wirebonding method for the position of each of said electrode pad and forming two or more wire bumps respectively The expanding section is formed by cutting, where a wire is expanded in each electrode pad about the bump of the part in which a piezo-electric diaphragm is not carried. The piezo-electric diaphragm by which electrode formation was carried out is carried in a table rear face in said wire bump's upper part. The manufacture approach of the piezoelectric transducer characterized by joining the electrode formed in the expanding section of said wire, and the front face of a piezo-electric diaphragm, and the electrode formed in the rear face of a piezo-electric diaphragm with the wire bump by ultrasonic thermocompression bonding or the ultrasonic welding method.

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the electric mechanical junction structure of a piezo-electric diaphragm and an electrode pad in more detail about piezoelectric transducers, such as a quartz resonator used for electronic equipment.

[0002]

[Description of the Prior Art] Although a piezoelectric transducer comes to contain a piezo-electric diaphragm (electronic device) in a package, since a component is an oscillating object, how it supports becomes the important element which determines the electrical characteristics. In the high quartz resonator of especially Q value, the supporting structure becomes important.

[0003] Connection between a piezo-electric diaphragm and the electrode for external derivation is made for example, with a conductive jointing material for corrugated fibreboard. The example of the quartz resonator of the surface mount mold which uses a conductive jointing material for corrugated fibreboard for drawing 8, and is performing electric mechanical junction is shown. The electrode pad 74 is formed in the top face of

a ceramic substrate 7, and it connects with the leading electrode 71 electrically through the beer electrode 73. Moreover, although the leading electrode 72 is not illustrated, it is connected with other electrode pads electrically mechanically. The Xtal diaphragm 8 with which the excitation electrodes 81 and 82 were formed in the table rear face is carried on the conductive jointing material for corrugated fibreboard S1, the conductive jointing material for corrugated fibreboard S2 is further applied to the upper part, and the electric mechanical connections of the Xtal diaphragm are carried out. And the Xtal diaphragm etc. is covered with a lid 9, a hermetic seal is carried out with Glass G, and a piezoelectric transducer is completed.

[0004] Although a conductive jointing material for corrugated fibreboard is the resin paste with which for example, the electric conduction filler was kneaded, handling has the troublesome side face. namely, -- although supply to a part for the joint of a conductive jointing material for corrugated fibreboard is performed by the dispenser -- the viscosity etc. -- the effect of the perimeter ambient atmosphere of temperature and humidity -- winning popularity -- easy -- a perimeter environment -- too little [ the oversupply of a jointing material for corrugated fibreboard, / supply ], and liquid -- whose nonconformity arises, the instability of such jointing-material-for-corrugated-fibreboard supply -- the variation in the electrical characteristics of a quartz resonator -- being connected -- moreover, liquid -- who might cause short circuit accident, such as inter-electrode

[0005] Moreover, since the tooth space for a conductive jointing material for corrugated fibreboard was needed at the time of junction, the spacing h between the Xtal diaphragm 8 and a lid 9 surely became large, and it had the problem that it could not respond to low back-ization of a piezoelectric transducer.

[0006] It is the object which solves such nonconformity, for example, a solder bump metallurgy bump is formed in JP,8-8684,A at an electrode pad, and how to carry out electric mechanical junction of the Xtal diaphragm by thermocompression bonding is considered. since such junction structure does not use a conductive jointing material for corrugated fibreboard -- too little [ the oversupply of a jointing material for corrugated fibreboard, / supply ], and liquid -- it had the advantage that the nonconformity produced conventionally [ such as whom, ] did not occur.

[0007] However, according to the above-mentioned approach, a device is needed for the electrode formed in the piezoelectric transducer. Namely, although each of two electrodes had to perform electric junction by the electrode pad side (rear-face side of a piezoelectric transducer), they needed to form the main electrode for excitation in the front flesh side in the piezo-electric diaphragm which excites a thickness skid oscillation, for example, and, for this reason, needed to take about the surface main electrode to the electrode pad side on the back. Formation of such a leading-about electrode takes about the vacuum evaporatio mask shape used at the time of the electrode thin film formation by a vacuum deposition method etc., and can be done

comparatively easily by forming an electrode. However, there was a thing in which it was formed and for which it takes about and an electrode is disconnected in the edge part of a piezoelectric transducer, in the required piezo-electric diaphragm of beveling processings, such as convex processing, the edge became sharper and the probability of a disconnection fault was high especially.

[0008] Moreover, although how to carry out electrical installation of an electrode pad and the main electrode by the side of a top face by wirebonding was also considered about the above-mentioned configuration, since it was necessary to make connection at process that the junction to an electrode pad and the main electrode by the side of an underside is another, it had the trouble which manufacture manday increases. Moreover, it had become the evil of thin-shape-izing of a package by existence of the deflection part of a wire.

[0009]

[Problem(s) to be Solved by the Invention] It was made in order that this invention might solve the above-mentioned trouble, and it is stabilized, junction of the electrode pad by the side of an insulating substrate and the electrode of a piezo-electric diaphragm can be performed, and it aims at offering the piezoelectric transducer which does not have an adverse effect on the various properties of a piezoelectric transducer, and the complicated junction approach does not need, either.

[0010]

[Means for Solving the Problem] At least two electrode pads formed in the top face of an insulating substrate and an insulating substrate as this invention was shown in claim 1, While at least two excitation electrodes are formed in a principal plane with at least two leading electrodes which are connected to each electrode pad and an electric target concerned, and are connected with the exterior, and two or more metal bumps formed in the top face of each of said electrode pad It consists of a piezo-electric diaphragm with which the drawer electrode which leads each excitation electrode concerned to the edge was formed. Said two or more metal bumps are the piezoelectric transducers which carry in the upper part and come to carry out electric mechanical connections to the metal bump concerned respectively a part about said piezo-electric diaphragm. Some metal bumps [ at least ] where a piezo-electric diaphragm is not located in the upper part among said two or more metal bumps [0011] to which it has the expanding section which the metal bump upper part elongated, and the expanding section concerned, the drawer electrode of the top face of said piezo-electric diaphragm and the drawer electrode located in the underside of a piezo-electric diaphragm at a list, and the metal bump are characterized by ultrasonic thermocompression bonding or carrying out ultrasonic welding Since the expanding section, the electrode of the top face of a piezo-electric diaphragm and the electrode located in the underside of a piezo-electric diaphragm at a list, and a metal bump are stuck by pressure or welded, each electrode etc. is firmly joined between metals by the above-mentioned configuration. Moreover,

since the tooth space of a conductive jointing material for corrugated fibreboard is not needed, spacing between the Xtal diaphragm and a lid can be made small, and it can respond also to thin shape-ization of a package.

[0012] Furthermore, the process which performs generating of the problem resulting from the amount of supply of a jointing material for corrugated fibreboard and hardening of a jointing material for corrugated fibreboard like [ at the time of using the conductive jointing material for corrugated fibreboard using a resin paste ] is not needed.

[0013] Moreover, as shown in claim 2, in a piezoelectric transducer according to claim 1, said metal bump is made into a wire bump, and said expanding section is good also as a configuration which are some wires. By the ball bonder which used the wirebonding technique, a wire bump is a bump who formed the metal wire in the rough convex form, forms the wire part at the head of heights for a long time, and can form the expanding section by melting by predetermined die length. Although the die length of the expanding section is 0.5-2mm, this die length is determined by terms and conditions, such as thickness of a piezo-electric diaphragm, and distance during a node.

[0014] Moreover, as shown in claim 3, in the piezoelectric transducer of claim 1 and two publications, the expanding section of a metal bump and a metal bump may consist of gold (Au) in the maximum upper layer of an electrode pad and a drawer electrode, and a list. It is junction by the same metal by this, and especially gold does not have the problem of oxidation and it has the advantage of excelling in junction nature.

[0015] As furthermore shown in claim 4, an above-mentioned piezoelectric transducer The insulating substrate by which at least two electrode pads were formed in the top face, and two or more leading electrodes which are connected to said each electrode pad and electric target, and are connected with the exterior were formed in the underside is installed in an activity stage. While using the wirebonding method for the position of each of said electrode pad and forming two or more wire bumps respectively The expanding section is formed by cutting, where a wire is expanded in each electrode pad about the bump of the part in which a piezo-electric diaphragm is not carried. The piezo-electric diaphragm by which electrode formation was carried out is carried in a table rear face in said wire bump's upper part. It is good to manufacture by the manufacture approach characterized by joining the electrode formed in the expanding section of said wire, and the front face of a piezo-electric diaphragm, and the electrode formed in the rear face of a piezo-electric diaphragm with the wire bump by ultrasonic thermocompression bonding or ultrasonic welding.

[0016]

[Embodiment of the Invention] The gestalt of operation of this invention is explained taking the case of the quartz resonator of a surface mount mold with drawing 1 , drawing 2 , drawing 3 , drawing 4 , and drawing 5 . Drawing 1 is the internal sectional view of a surface mount mold quartz resonator, and is an A-A sectional view at the time of carrying a piezo-electric diaphragm in drawing 2 , and closing with a lid. Drawing 2

is the top view which decomposed the Xtal diaphragm and the insulating substrate, and [drawing 3](#) , [drawing 4](#) , and [drawing 5](#) are drawings showing a production process.

[0017] A surface mount mold quartz resonator consists of each metal bumps 31, 32, and 33 who intervene between an insulating substrate 1, the Xtal diaphragm 2 by which is carried in the electrode pads 14 and 14 formed on the insulating substrate 1, and electric junction is carried out, and the electrode pads 14 and 14 of an insulating substrate 1 and the Xtal diaphragm 2, and a lid 4 which carries out the hermetic seal of the Xtal diaphragm 2.

[0018] An insulating substrate 1 consists of ceramic sheet metal, such as a rectangular alumina, and the electrode pads 14 and 14 are formed in the front face together with the cross direction (the direction of a shorter side) of an insulating substrate. Moreover, leading electrodes 11 and 12 are formed in the rear face, and response connection is electrically made through said electrode pads 14 and 14 and beer electrode 13, respectively. Each [ these ] electrode is formed using a well-known metallizing technique, a plating technique, etc., for example, a tungsten layer is given to a lower layer and the gold layer is given to the upper layer. The metal bumps 31, 32, and 33 who consist of a wire bump who used the golden wire are formed in the top face of each electrode pad. These wire bump is also called a stud bump, using a wirebonding technique, makes it the shape of a ball by heating the head of a golden wire with a diameter of about 50 microns, and is obtained after connecting with an electrode pad by performing cutting of a wire by part for a bump direct near part. Although the obtained metal bump turns into 100 micron of \*\*\*\*, and about [ height 60 micron ] \*\*\*\*\* PU, this magnitude is the wire size of a wire. It can change suitably by choosing and adjusting the sticking-by-pressure force, sticking-by-pressure time amount, etc. Among these metal bumps, although cutting of a wire is performed by part for a bump direct near part, cutting of a wire is performed for example, in 0.5-2mm upper part, and, as for the metal bumps 31 and 32, expanding section 33a with a wire is formed, as for the metal bump 33 by whom the Xtal diaphragm 2 is not carried.

[0019] The excitation electrodes 21 and 22 are formed in the table rear faces of each so that the Xtal diaphragm 2 may consist of a rectangle AT cut quartz plate, for example, a thickness skid oscillation may be excited, and the drawer electrodes 21a and 22a are drawn from each excitation electrodes 21 and 22 by the longitudinal direction of the Xtal diaphragm. Moreover, drawer electrode 21b is formed in a part of rear face corresponding to drawer electrode 21a, and drawer electrode 22b is formed in a part of front face corresponding to drawer electrode 22a. In addition, the dimension of the Xtal diaphragm is constituted from die length of 4mm, and width of face of 1.6mm by the thickness which obtains the frequency of 32MHz, and a lower layer consists of chromium and, as for each excitation electrode and a drawer electrode, the upper layer is constituted from this example bygold.

[0020] A lid 4 consists of insulating materials, such as a ceramic, the cross-section

configuration has become reverse concave-like, and the Xtal diaphragm 2 forms the space by which a hermetic seal is carried out.

[0021] Next, a metal bump is formed in an insulating substrate 1, the Xtal diaphragm 2 by which electrode formation was carried out is carried in an insulating substrate 1, and the example of the approach of carrying out electric mechanical connections is explained with [drawing 3](#) , [drawing 4](#) , and [drawing 5](#) . As shown in [drawing 3](#) , an insulating substrate 1 is installed on the activity stage W, and two or more metal bumps (golden wire bump) are continuously formed of the bump bonder using wirebonding techniques, such as thermocompression bonding, on the electrode pad 14. Among these, expanding section 33a is formed in the metal bump 33 by the side of the longitudinal direction edge of the Xtal diaphragm. Wire cutting is not carried out right above [ bump ], but formation of this expanding section 33a is formed by melting, after pulling out the wire of a predetermined dimension, after forming a metal bump. In addition, the inside T of [drawing 3](#) is a bonding tool (capillary). Next, the Xtal diaphragm 2 is carried so that the drawer electrodes 21b and 22a may touch on each metal bump 31 and 32, respectively. In addition, when doing this activity with an automatic loading machine, it is possible to control not to be carried on the bump who has the expanding section by using the number of bumps, a location, etc. as a marker.

[0022] Then, ultrasonic welding of the drawer electrode on expanding section 33a and the Xtal diaphragm, and the metal bumps 31 and 32 and the drawer electrode of the Xtal diaphragm is carried out by the ultrasonic welder. In more detail, by welding tip C of an ultrasonic welder, expanding section 33a which stands straight is bent and contacted to the drawer electrode on the Xtal diaphragm, the Xtal diaphragm is pushed on a bump as it is, and static pressure is impressed. And ultrasonic welding of the drawer electrode on expanding section 33a and the Xtal diaphragm and the drawer electrode of the metal bumps 31 and 32 and the Xtal diaphragm is carried out by vibrating an ultrasound tip on a predetermined frequency.

[0023] In addition, it is not necessary to necessarily form the expanding section corresponding to each drawer electrode, and may be formed only in the side to which a main electrode corresponds to connection of the part in a front face (side which does not have an electrode pad) in the configuration in which the main electrode was respectively formed in the front flesh side one like this example.

[0024] The hermetic seal of the Xtal diaphragm 2 by which ultrasonic welding was carried out on the electrode pad of an insulating substrate 1 is carried out with a lid 4. Although junction on insulating-substrate 1 lid 4 is performed by glass 41, other hermetic seal means, such as resistance welding, may be used, for example.

[0025] The gestalt of other operations of this invention is explained with [drawing 6](#) . [Drawing 6](#) shows the modification of a bump configuration. Since the basic configuration is the same as the gestalt of the above-mentioned implementation, a part for the same structured division omits explanation in part while explaining it using a

jack per line.

[0026] The bump group 51 relevant to loading of the piezo-electric diaphragm 2 and the bump group 52 which consists of two or more bumps who do not participate in loading but have the expanding section relevant to electrical installation are formed in the electrode pad 14. The bump group 51 is the configuration that the minute bump ranked with two trains, and the bump group 52 also has two or more expanding section 52a. Two or more expanding sections are bent in the direction of arrow-head D, respectively, and are connected with the drawer electrode of a piezo-electric diaphragm. Joining of the these expanding section 52a is carried out to the front face of a drawer electrode by the ultrasonic welder.

[0027] The gestalt of operation of another others of this invention is explained with drawing 7. Drawing 7 shows another modification of a bump configuration. Since the basic configuration is the same as the gestalt of above-mentioned 2 operations, a part for the same structured division omits explanation in part while explaining it using a jack per line.

[0028] The electrode pad 14 is formed so that it may be located in the vertical angle of a rectangle piezo-electricity diaphragm. Thus, this invention can be applied not only when carrying out the cantilevered suspension of the piezo-electric diaphragm but when carrying out ends support. In this example, the bump group 53 relevant to loading of the piezo-electric diaphragm 2 and the bump group 54 which consists of two or more bumps who do not participate in loading but have the expanding section relevant to electrical installation are formed, and the bump groups 53 and 54 incline toward the edge of the direction of a shorter side of a piezo-electric diaphragm (cross direction), and are arranged at it. Two or more expanding sections are bent by an arrow head D1 and D 2-way, respectively, and are connected with the drawer electrode of a piezo-electric diaphragm. Joining of the these expanding section 52a is carried out to the front face of a drawer electrode by the ultrasonic welder.

[0029] In addition, although the metal bump who uses it in the above-mentioned example may use other ingredients, such as not only gold but copper, aluminum, etc., a oxidation reduction ambient atmosphere may be needed depending on the ingredient to be used. Moreover, although it is desirable to use this ingredient with a metal bump as for connected electrodes, such as an electrode pad and a drawer electrode, the upper layer of a drawer electrode is used as silver in the first example, and the possible thing can also be checking experimentally junction by the dissimilar metal using a golden bump, for example.

[0030] Moreover, what is necessary is just to form a metal bump's formation by thermocompression bonding, ultrasonic thermocompression bonding, an ultrasonic welding method, etc. Moreover, although the piezo-electric diaphragm which used the thickness skid oscillation was illustrated in each above-mentioned example, when carrying out the cantilevered suspension of the tuning fork mold vibrator using a

crookedness oscillation, you may apply to the piezo-electric diaphragm of other oscillation modes, for example.

[0031]

[Effect of the Invention] Since the expanding section, the electrode of the top face of a piezo-electric diaphragm and the electrode located in the underside of a piezo-electric diaphragm at a list, and a metal bump are stuck by pressure or welded, each electrode etc. is firmly joined between metals by the above-mentioned configuration. Moreover, the need of taking the problem of cutting of an edge part into consideration is lost. Therefore, the instability of the junction generated conventionally is canceled and the piezoelectric transducer by which electrical characteristics were stabilized can be obtained. Moreover, since the process which hardens a jointing material for corrugated fibreboard is not needed while being able to respond also to thin shape-ization of a package, manufacture manday is also reduced and productivity improves.

[0032] Moreover, since according to claim 2 a bump can be formed very easily and a formation location, bump size, etc. can be determined as arbitration by using the wire bump adapting a wirebonding technique as a metal bump in addition to the above-mentioned effectiveness, adjustment of sticking by pressure and joining can be performed simple. Moreover, formation of the expanding section can also set up the die length of arbitration, and can be made to correspond to terms and conditions, such as thickness of a piezo-electric diaphragm, and inter-electrode distance, flexibly.

[0033] Moreover, according to claim 3, in addition to the above-mentioned effectiveness, junction nature improves by using gold. Moreover, if the field which touches the metal bump of the electrode of an electrode pad or a piezo-electric diaphragm is also constituted from gold, junction nature will improve further.

[0034] Furthermore, since according to claim 4 it is the manufacture approach which forms the expanding section by cutting where a wire is expanded in each electrode pad about the bump of the part in which a piezo-electric diaphragm is not carried while using the wirebonding method for the position of each of said electrode pad and forming two or more wire bumps respectively, formation of a wire bump and the expanding section can form certainly very efficiently. Moreover, since the electrode formed in the expanding section of said wire and the front face of a piezo-electric diaphragm and the electrode formed in the rear face of a piezo-electric diaphragm with the wire bump are joined by thermocompression bonding or the ultrasonic welding method, it can carry out certainly in the field where junction is comparatively small.

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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] The internal sectional view by the gestalt of the 1st operation.

[Drawing 2] The top view by the gestalt of the 1st operation.

[Drawing 3] Drawing showing a production process.

[Drawing 4] Drawing showing a production process.

[Drawing 5] Drawing showing a production process.

[Drawing 6] The top view showing the gestalt of other operations.

[Drawing 7] The top view showing the gestalt of operation of another others.

[Drawing 8] Drawing showing the conventional example.

[Description of Notations]

1 Insulating Substrate

2 Piezo-electric Diaphragm (Xtal Diaphragm)

31, 32, 33 Metal bump (wire bump)

33a Expanding section

4 Lid

51, 52, 53, 54 Bump group

52a Expanding section